

METHOD AND SYSTEM FOR VIDEO OBJECT RANGE SENSING

FIELD OF THE INVENTION

The invention relates to a method for discriminating the range of objects captured by an image or video camera using active illumination from a computer display. This method can be used to aid in vision based segmentation of objects.

BACKGROUND OF THE INVENTION

Range sensing techniques are useful in many computer vision applications. Vision-based range sensing techniques have been investigated in the computer vision literature for many years; for example, they are described in D. Ballard and C. Brown, Computer Vision, Prentice Hall, 1982. These techniques require either structured active illumination projectors as in K. Pennington, P. Will, and G. Shelton, "Grid coding: a novel technique for image analysis. Part 1. Extraction of differences from scenes", IBM Research Report RC-2475, May, 1969; M. Maruyama and S. Abe, "Range sensing by projecting multiple slits with random cuts", IEEE Trans. on Pattern Analysis and Machine Intelligence, Vol. 15, No. 6, pp. 647-651, June, 1993; and U. S. Patent 4,269,513 "Arrangement for Sensing the Surface of an Object Independent of the Reflectance Characteristics of the Surface", P. DiMatteo and J. Ross, May 26, 1981, or multiple input camera devices as in J. Clark, "Active photometric stereo", Proceedings IEEE Computer Society Conference on Computer Vision and Pattern Recognition, pp. 29-34, June, 1992; and Sishir Shah and J. K. Aggarwal, "Depth estimation using stereo fish-eye lenses, IEEE International Conference on Image Processing, Vol. 1, pp. 740-744, 1994; or cameras with multiple focal depth adjustments as in S. Nayar, M. Watanabe, and M. Noguchi, "Real-time focus range sensor", IEEE Trans. on Pattern Analysis and Machine Intelligence, Vol. 18, No. 12, pp. 1186-1197, 1996; all of which are expensive to implement.

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The present invention's focus is on range sensing methods that are simple and inexpensive to implement in an office environment. The motivation is to enhance the interaction of users with computers by taking advantage of the image and video capture devices that are becoming ubiquitous with office and home personal computers. Such an enhancement could be, for example, windows navigation using human gesture recognition, or automatic screen customization and log-in using operator face recognition, etc. To implement these enhancements, we use computer vision techniques such as image object segmentation, tracking, and recognition. Range information, in particular, can be used in vision-based segmentation to extract objects of interest from a sometimes complex environment.

To sense range, Pennington et al. cited above, uses a camera to detect the reflection patterns from an active source of illumination projecting light strips. For this technique to work, it is required to project a slit of light in a darkened room or to use a laser-based light source under normal room illumination. Clearly, none of these options are practical in the normal home or office environment.

Accordingly, the present invention envisions a novel and inexpensive method for range sensing using a general-purpose image or video camera, and the illumination of a computer's display as an active source of lighting. As opposed to Pennington's method which uses light striping, we do not require that the display's illumination have any special structure to it.

SUMMARY OF THE INVENTION

In one embodiment of this invention, the difference is computed between two consecutive digital images of a scene, captured using a single camera located next to a display, and using the display's brightness as an active source of lighting. For example, the first image could be captured with the display set to a black background, whereas the second image could have the display set to a white background. The display's light is reflected back to the camera and, consequently, the two consecutive images'

difference will depend on the intensity of the display illumination, the ambient room light, the reflectivity of objects in the scene, and the distance of these objects from the display and the camera. Assuming that the reflectivity of objects in the scene is approximately constant, the objects which are closer to the display and the camera will reflect larger light differences between the two consecutive images. After thresholding, this difference can be used to segment candidates for the object in the scene closest to the camera. Additional processing is required to eliminate false candidates resulting from differences in object reflectivity or from the motion of objects in the two images. This processing is described in the detailed description.

Briefly stated, the broad aspect of the invention is a method and system for video object range sensing comprising a computer having a display; a video camera for receiving or capturing images of objects in an environment, the video camera being connected to the computer wherein the computer display's brightness is operable as an active source of lighting.

The forgoing and still further objects and advantages of the present invention will be more apparent from the following detailed explanation of the preferred embodiments of the invention in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram of a preferred embodiment of the system of the present invention in an office environment.

Fig. 2 is a flow chart of the method carried out by the system seen in Fig. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

We consider an office environment where the user sits in front of his personal computer display. We assume that an image or video camera is attached to the PC, an

Fig. 1 is a schematic diagram of a system, according to the present invention, for determining range information of an interested object 2. The object 2 can be any object, for example, a user's hand. Object 2 is subjected to light 10 generated by computer display 4. The brightness of the computer display 4 is controlled by a computer 8 through line 18. The light 10 illuminates the surface of object 2, generating reflection as shown by arrows 12. The reflection 12 sensed by a camera 6 is represented by arrow 14. The camera 6 captures images and transmits them to a computer 8 for processing through line 16.

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Morphological operations such as dilation and erosion are then used to further remove noise from the segmentation image as indicated by block 52. For example, we also measure the size of each connected object. The objects with significant smaller sizes are then removed. The resulting image which is considered as the segmentation of the object in the scene closest to the camera and display can be sent, as indicated by line 54, to a device indicated by block 56. The device can be a visual display on a terminal, or can be an application running on a computer, or the like.

This method can be extended in different ways but still remain within the scope of this invention. For example, instead of using only two consecutive images taken under different computer displays' illumination, other options are having integration of several images to reach different desired illumination, or having structured computer display illumination aided by integration to remove camera noise.

Applications of the system are targeted for the emerging human-computer gesture interaction. Substantial value would be added to personal computer products that would be capable of allowing human use gesture to control graphical user interface in computers.

The system can also be used for screen saver applications. Screen saver applications are activated when keyboard/mouse are idle for a preset idle time. This becomes very annoying when a user needs to look at the contents on the display and no keyboard/mouse actions are required. The invention can be used to detect whether a user is present and, in turn, to decide whether a screen saver application need to be activated.

The invention having been thus described with particular reference to the preferred forms thereof, it will be obvious that various changes and modifications may be made therein without departing from the spirit and scope of the invention as defined in the appended claims.